inVentures Technologies incorporated

Creating Value Through inNovation

www.gasinfusion.com

Co-inFusion of Oxygen and Alkane Gas for Bioremediation of Groundwater Pollutants

Introduction

Aerobic cometabolic treatment of groundwater contaminants entails biostimulation of indigenous soil bacteria by adding oxygen and a growth substrate to trigger the production of enzymes that can oxidize the target pollutant via cometabolism. The method is most useful for bioremediation of pollutants that are not themselves good growth substrates for bacteria. With this approach, the added substrate serves as both the electron donor and primary growth substrate for the bacteria. Oxygen is the final electron acceptor in the process.

Cometabolic treatment has been found to be particularly effective for the chlorinated solvent trichloroethylene (TCE) and other lower chlorinated aliphatic hydrocarbons (DCE, VC, TCA, DCA, CF, and MC)*****. The process has also been found to be effective for treatment of groundwater contaminated with the gasoline additive MTBE and other persistent organic compounds such as pesticides. At some sites with mixed groundwater contaminants (i.e. petroleum hydrocarbons with chlorinated solvents or MTBE), the necessary substrate for inducing aerobic cometabolism of the target pollutant may already be present and all that is needed is the infusion of oxygen**. Various aliphatic and aromatic hydrocarbon compounds have been found to function as cometabolic treatment substrates and significant research and development has focused on the use of alkane gases (i.e. methane and propane) for the purpose.

Process Description

Cometabolic treatment by direct infusion (Co-inFusion) of oxygen and gaseous cometabolic substrates through iSOC units is a straightforward process to treat recalcitrant groundwater contaminants. The process involves the configuration of iSOC treatment wells to deliver oxygen and an alkane gas to the groundwater treatment area. The iSOC units are placed in treatment wells and provide an inherently large surface area that allows for oxygen and alkane gas delivery by direct contact with groundwater and ultra efficient mass transfer without bubbles.

The treatment area established by Co-inFusion can be designed as a grid to treat source areas and/or as a treatment curtain or fence of treatment wells to cut off plume migration.

Advantages of Co-inFusion Treatment

Cometabolic treatment has significant advantages over other bioremediation approaches for persistent groundwater contaminants. These advantages include:

- Ability to treat compounds generally not subject to direct aerobic oxidation
- Rapid increases in useful biomass through biostimulation of indigenous bacteria
- Rapid and complete biodegradation of target pollutants due to regular input of cometabolic substrate (bacteria grow on the added substrate, not the diminishing target pollutant)
- No problems with build-up of recalcitrant daughter products (the aerobic degradation pathway for TCE does not produce DCE and VC stall)
- Improved bacterial growth due to stimulation of nitrogen fixation by alkane-utilizing bacteria

Key Design Criteria

Key design criteria for Co-inFusion include iSOC well placement and oxygen and cometabolic growth substrate infusion rates. Oxygen is infused at the standard iSOC rate of 15 cc/minute to achieve supersaturated conditions. The alkane gas is infused intermittently at stoichiometric equivalent rates to provide optimal growth of soil bacteria under aerobic conditions.

The design may include placement of two iSOCs, one for oxygen and one for the alkane gas, in the same treatment well or placement in separate wells with the alkane gas infusion wells located just up gradient of the oxygen infusion wells. The intermittent infusion of the alkane gas minimizes competitive inhibition (competition for enzymes between the substrate and the target contaminant). Gas infusion rates should take into account the relative solubility of pure oxygen and the selected alkane gas. For instance, with a water column of five feet in a well above the iSOC unit, a concentration of 42 mg/L of oxygen can be achieved in groundwater. At the same depth, the concentration of propane infused to the water in the well would be 66 mg/L. In this case, placement of the oxygen iSOC unit at a greater depth than the propane unit will maximize the infusion of oxygen relative to propane.

Performance monitoring wells should be placed crossgradient to assess the area of influence, and downgradient based on the direction of groundwater flow. Monitoring parameters should include at, a minimum, dissolved oxygen, the selected growth substrate, and the target contaminant concentrations.

Notes:

1. The highly oxidized tetrachloroethylene (PCE) is not treated by this process, but is subject to the anaerobic process of reductive dechlorination, which can be implemented by direct infusion of a carbon substrate such as an alkane gas without oxygen. The daughter products of PCE reductive dechlorination, DCE and VC, which are often persistent under anaerobic conditions, are readily treated by aerobic Co-inFusion.
2. A bioremediation system for groundwater pollutants such as petroleum hydrocarbons that are subject to direct aerobic oxidation may also be improved by the addition of the cometabolic substrate due to the rapid increase in biomass that results from addition of high bioavailability alkane gas.